MALACOLOGIA, 2010, 53(1): 61–76

PALEOECOLOGICAL AND PALEOBIOGEOGRAPHIC SIGNIFICANCE OF TWO NEW SPECIES OF BIVALVES IN THE PARANÁ FORMATION (LATE MIOCENE) OF ENTRE RÍOS PROVINCE, ARGENTINA

Leandro M. Pérez[1*, 2], Santiago F. Genta Iturrería[1, 3] & Miguel Griffin[1, 2]

ABSTRACT

Two new species are described based on material from the Late Miocene Paraná Formation, Entre Ríos, Argentina: ***Polymesoda muravchiki***, nov. sp., and ***Erodona doellojuradoi***, nov. sp. The bearing rocks were deposited during the Entrerriense ingression that covered part of central-northern Argentina, reaching as far north as Bolivia, Paraguay, and southern Brazil. The exposure from where the material was collected represents a rich parautochtonous assemblage – also including marine taxa – that has been assigned to the Late Miocene. Extant representatives of *Polymesoda* and *Erodona* are known to inhabit mostly brackish environments in the Caribbean region, the eastern Pacific coast of America, and Southeast Asia (in the case of *Polymesoda*), and the Atlantic coast of southern South America (*Erodona*). The presence of these bivalves in the Paraná Formation suggests that at least a marginal connection may have existed between a southern arm of the Amazonian Sea and the Paraná Sea during the Miocene. It is highly unlikely that these taxa could have migrated along the Atlantic coast of South America – contrarily to the case of the fully marine taxa – in view of their peculiar ecological requirements.

Key words: bivalves, *Polymesoda*, *Erodona*, Paraná Formation, Late Miocene, Entre Ríos.

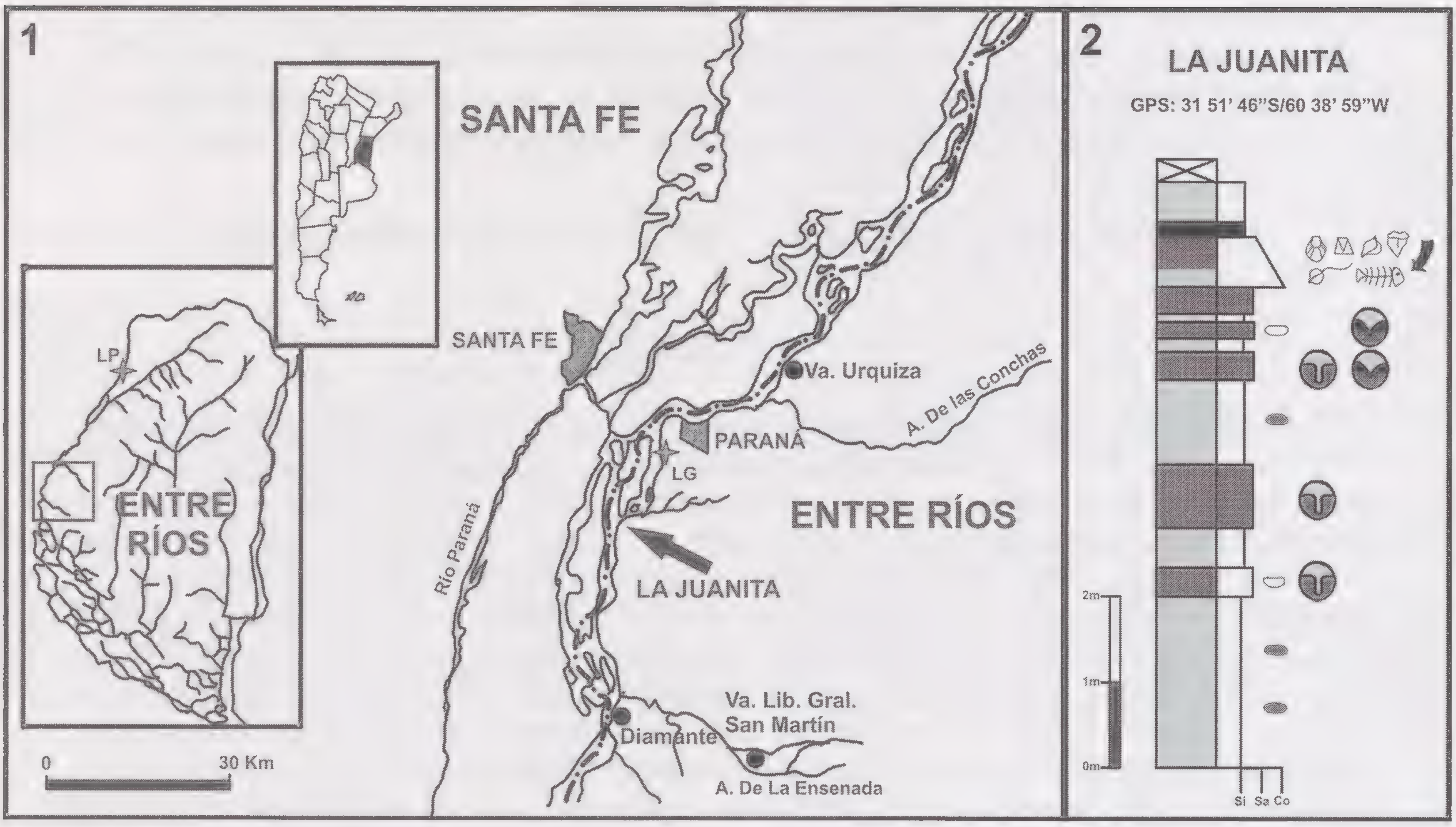
INTRODUCTION

The marine deposits of the Paraná Formation have been known since the first half of the Nineteenth Century under such names as Entrerriense-Rionegrense, Mesopotamiense, Formación Entre Ríos, and Formación Entrerriana. Alcide d'Orbigny surveyed the area in 1827, and shortly after that it was also visited by Charles Darwin in 1833 (Darwin, 1839). D'Orbigny collected fossils at Bajada Grande (presently the city of Paraná), and he published the descriptions of his material (d'Orbigny, 1842). Darwin, while recognizing the presence of mollusks in the rocks exposed at Bajada Grande, did not provide descriptions or illustrations of any specimens, although he did comment on the geology of the area (Darwin, 1846). Later contributions towards the geological and paleontological knowledge of the area are – among others – Bravard (1858), Philippi (1893), Borchert (1901), Ameghino (1906), Ihering (1907), Frenguelli (1920, 1947), Kantor (1925), Cordini (1949), Camacho (1967a, b), Yrigoyen (1969), Iriondo (1973), Aceñolaza (1976, 2000), Aceñolaza & Sayago (1980), del Río (1990, 1991), del Río & Martínez Chiappara (1998a, b), Aceñolaza & Aceñolaza (2000), Cione et al. (2000), and Muravchik et al. (2004). The age of the Paraná Formation has been a matter of debate over the years and remains to be completely elucidated. However, most authors agree it was deposited during the Middle Miocene (Aceñolaza, 2000; Aceñolaza & Aceñolaza, 2000; del Río, 2000), or Late Miocene (Camacho, 1967a; Zabert, 1978; Cione et al., 2000).

In this paper we describe a new species of *Polymesoda* Rafinesque, 1828, and a new species of *Erodona* Bosc, 1802. The material was collected from rocks referred to the Paraná Formation exposed at La Juanita (31°52'46"S; 60°38'59"W) (Pérez et al., 2001 and Cione et al., 2008) (Fig. 1), the type locality of the new taxa described. The new species of *Polymesoda* has been reported recently from this lithostratigraphic unit by Pérez et al. (2008), and the presence of the new species of *Erodona*

---

[1] División Paleozoología Invertebrados, Museo de Ciencias Naturales de La Plata, Paseo del Bosque s/n., Argentina
[2] Consejo Nacional de Investigaciones Científicas y Técnicas (CONICET)
[3] Agencia Nacional de Promoción de Ciencia y Técnica (ANPCyT)
*Corresponding author: pilosaperez@gmail.com



FIGS. 1, 2. Studied area. FIG. 1: Location map of the studied area; FIG. 2: Schematic section showing the most important lithologies exposed at "La Juanita" (LP: La Paz; LG: Los Galpones).

by Pérez et al. (2001, 2005). Aceñolaza (2004) also subsequently mentioned the presence of *Erodona* in this stratigraphic unit.

We also discuss the paleoecologial and paleobiogeographic implications of the presence of these new taxa in the Paraná Formation.

STRATIGRAPHIC SECTION

La Juanita is a locality near Aldea Brasilera village in the Department of Diamante, Entre Ríos Province. At this locality lie exposed eight meters of the Paraná Formation along the lower

TABLE 1. Measurements of specimens of ***Polymesoda muravchiki*** nov. sp. (in mm).

Collection Nº	Height	Length	Width	Observations
MAS-PI-001 HT	23.96	29.17	6.29	left valve, complete
MAS-PI-002	23.52	28.79	6.15	left valve, ventral margin broken
MAS-PI-003	14.42	16.93	3.63	left valve, complete
MAS-PI-004	15.75	18.42	4.03	left valve, anterior margin broken
MAS-PI-005	15.59	17.15	3.89	left valve, ventral margin broken
MAS-PI-006	19.55	*	4.42	left valve, posterior margin broken
MAS-PI-007	*	22.17	4.33	left valve, ventral margin broken
MAS-PI-008	23.12	28.74	6.14	right valve, complete
MAS-PI-009	18.54	21.39	4.84	right valve, complete
MAS-PI-010	16.81	19.25	4.33	right valve, complete
MAS-PI-011	17.28	19.94	4.26	right valve, complete
DMT-PI-001	24.47	28.29	6.32	left valve, complete
DMT-PI-006	22.05	28.73	6.52	right valve, complete

TABLE 2. Measurements of specimens of ***Erodona doellojuradoi*** nov. sp. (in mm).

Collection N°	Height	Length	Width	Observations
MAS-PI-327 HT	11.19	22.06	3.91	left valve
MAS-PI-342	12.85	24.23	4.52	left valve
MAS-PI-348	12.39	21.09	4.05	left valve
MAS-PI-375	12.17	21.36	4.24	left valve
DMT-PI-145	13.17	23.63	4.49	left valve
DMT-PI-159	14.28	24.27	5.44	left valve
DMT-PI-166	8.56	15.78	3.07	left valve
MAS-PI-398	18.47	30.82	6.18	right valve
MAS-PI-399	16.24	25.63	5.08	right valve
MAS-PI-437	14.76	25.19	4.19	right valve
DMT-PI-188	15.75	26.89	4.99	right valve
DMT-PI-194	13.82	21.38	4.11	right valve
DMT-PI-217	13.72	25.06	3.65	right valve

part of the riverbank (Fig. 2). The section begins with alternating white to yellowish sands and green siltsones, very bioturbated by *Ophiomorpha* isp., followed by an erosional bed of lenticular geometry and laterally continuous for about 100 m. This bed shows normal gradation with a sabulitic matrix at the bottom and grading upwards to a sandy bed. Towards the middle part, the sandy matrix is strongly cemented by carbonate. The thickness of this bed reaches about 50 cm, and it contains the remains of the *Polymesoda* and *Erodona* described herein. These are associated to a fairly rich fauna of other invertebrates and vertebrates. The base of the section is usually covered by debris fallen from the adjoining cliff or by river during floods. The top is covered by vegetation.

MATERIALS AND METHODS

The described specimens were recovered after washing shells and sediment from the shell bed, using a dilute solution of H_2O_2. Valve measurements were taken using a 0–150 mm digital caliper. Specimens were observed under light microscopy and photographed using a digital camera. Measurements (Tables 1, 2) are taken according to Stanley (1970). Dimensions are in millimeters. Abbreviations used are L = length; H = height; W = width.

Acronyms

All examined material is housed in the collection of the División Paleozoología Invertebrados at the Museo de La Plata (MLP), the Museo Argentino de Ciencias Naturales "Bernardino Rivadavia" (MACN), the Museo de Ciencias Naturales y Antropológicas "Prof. Antonio Serrano", Paraná, Entre Ríos (MAS), and the Centro de Investigaciones Científicas y de Transferencia Tecnológica a la Producción (CICYTTP), CONICET, Diamante, Entre Ríos (DMT).

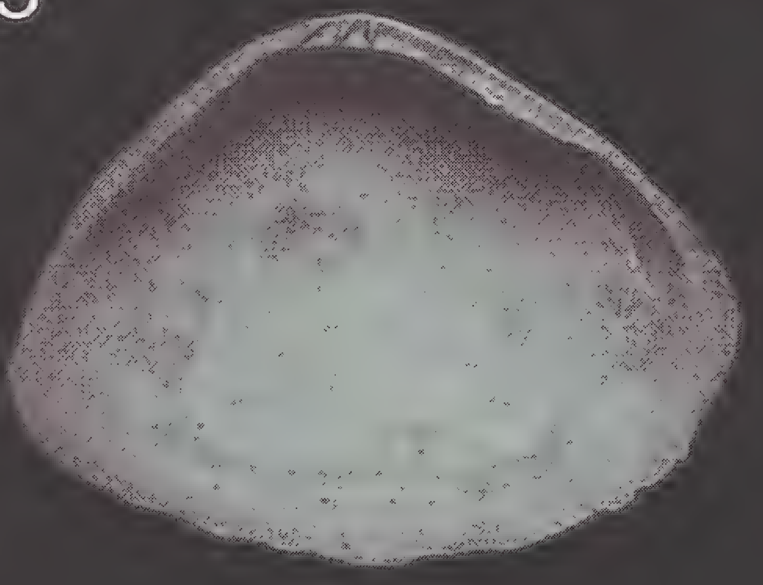
SYSTEMATIC PALEONTOLOGY

Class BIVALVIA
Order VENEROIDA
Superfamily CORBICULOIDEA
Family CYRENIDAE
Genus *Polymesoda*, Rafinesque, 1828
Type Species *Cyclas caroliniana* Bosc, 1802,
by original designation

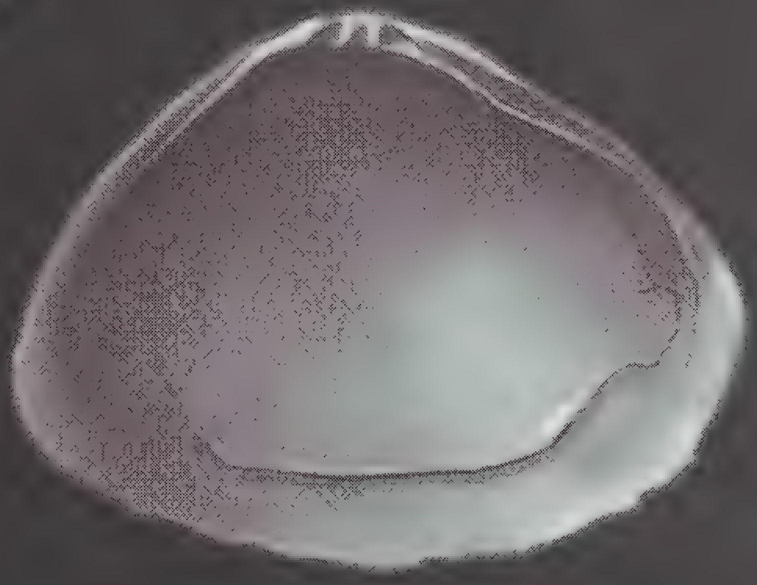
Polymesoda muravchiki, nov. sp.
FIGS. 3–10

Material: Thirteen specimens: eight left valves, of which three are complete and five broken; five complete right valves.

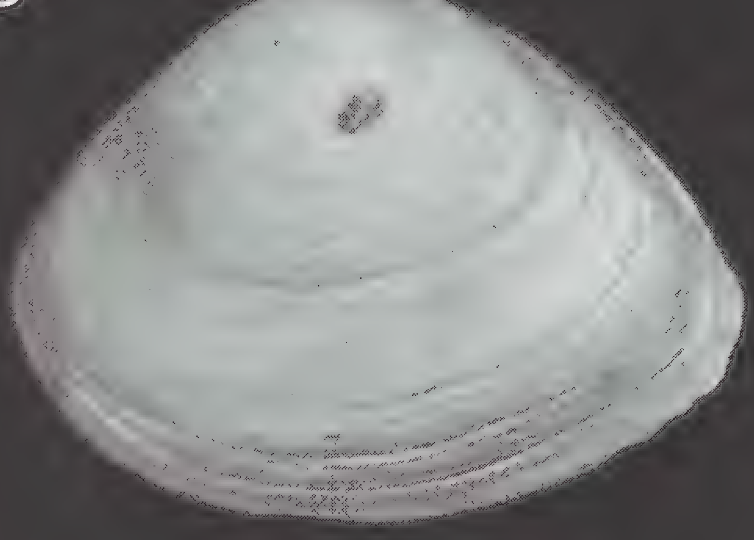
3



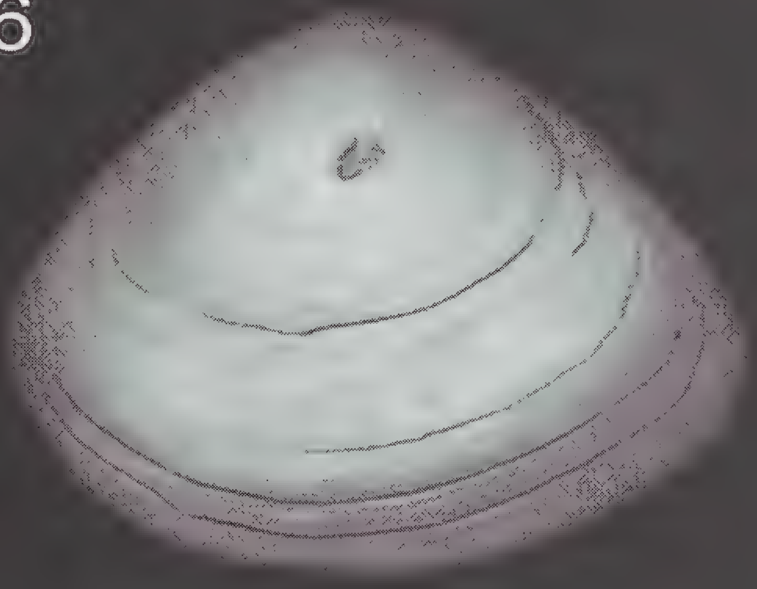
4



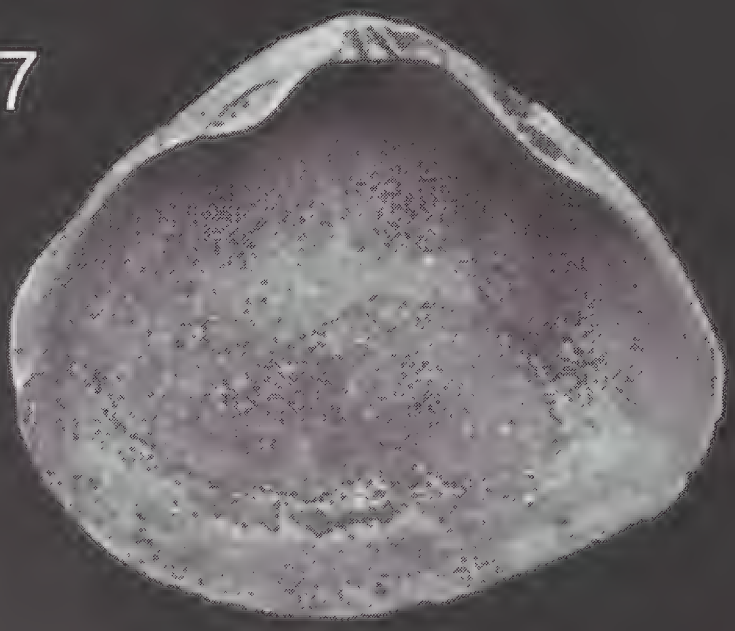
5



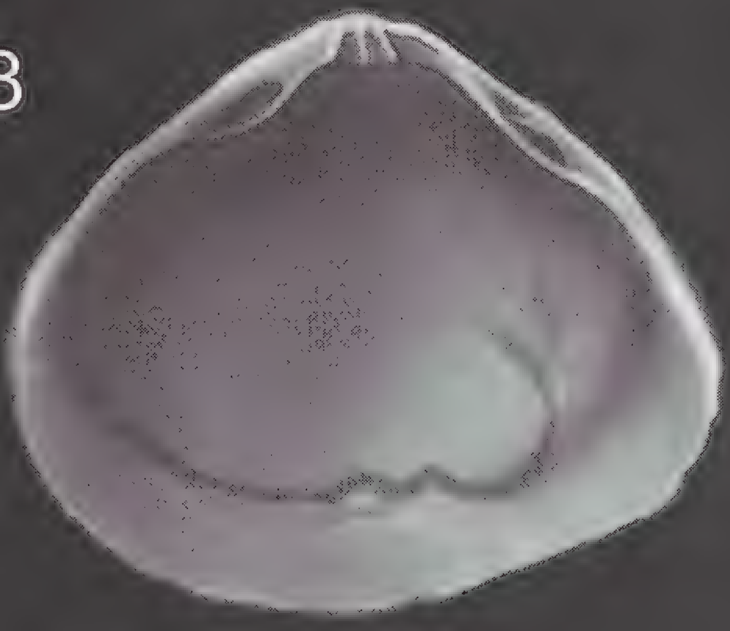
6



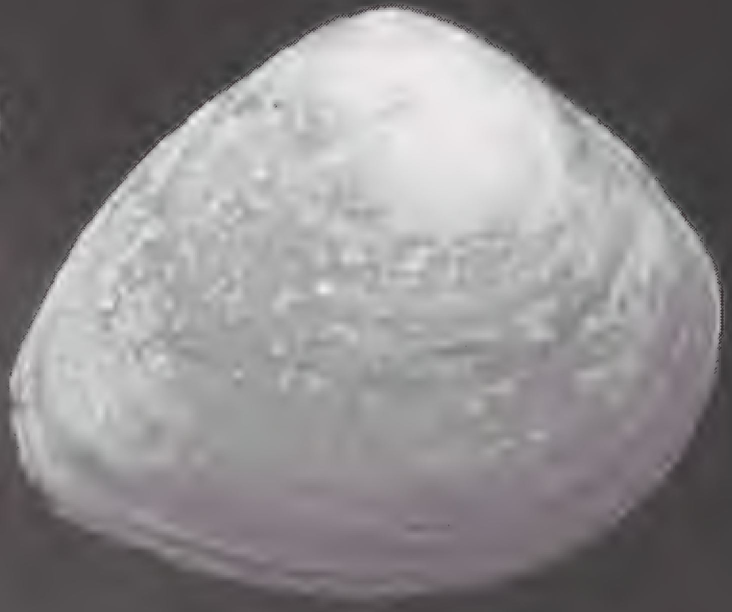
7



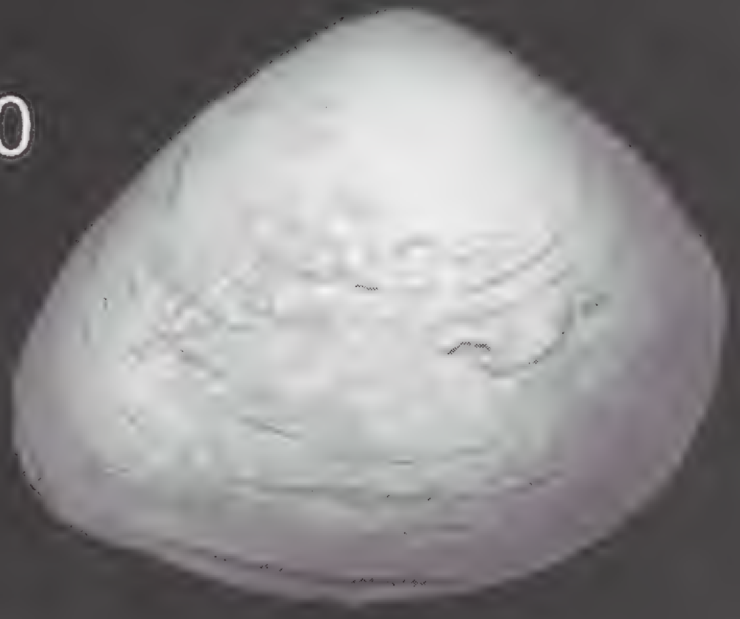
8



9



10



Type Material: Holotype, MAS-PI-001 a left valve; all other specimens are paratypes, MAS-002-011, DMT-PI-001and DMT-PI-006.

Type Locality: La Juanita (31°52'46"S, 60°38'59"W), Aldea Brasilera, Diamante Department, Entre Ríos Province, Argentina.

Occurrence: This new species is found only within the Paraná Formation at La Juanita and is thus far represented by only 13 valves.

Etymology: After Martín Muravchik, who was instrumental in collecting the specimens described.

Diagnosis: *Polymesoda* with equilateral and triangular shells with convex ventral margin, laterally compressed, height 82% of length; umbo low, non-protruding, mesogyrous; ornamentation of weak commarginal lines; left valve anterior and middle cardinal teeth short, small, lamellar, subparallel and vertical; left valve posterior cardinal tooth flattened and defining a small cavity parallel to posterodorsal margin; nymphae narrow.

Description: Shell small-sized for genus (17 to 29 mm long), triangular, nearly as high as long; shell laterally compressed; umbones mesogyrous located at mid-length of valves; anterior dorsal margin moderately convex; posterodorsal margin straight to slightly convex, descending steeply to join regularly convex ventral margin; posterior end slightly truncate; ornamentation of very delicate commarginal lines; adductor muscle scars deeply impressed, similar in size; left valve cardinal teeth three, the anterior and the middle teeth sharp and lamellar and the posterior tooth very weak, barely differentiated from the narrow hinge plate that separates it from the nymph; right valve cardinal teeth three, lamellar and weak (Figs. 7, 8); left valve anterior and posterior lateral teeth elongate, smooth, adjacent to inner surface of shell; left valve anterior lateral stronger and half as long as posterior tooth; right valve with two anterior parallel lateral teeth and two parallel posterior teeth; inner lateral teeth lamellar and much stronger than external ones, which are almost obsolete and barely differentiated from the hinge plate; nymph short and narrow, widening posteriorly and almost reaching proximal end of posterior lateral tooth.

Measurements: HT (MAS-PI-001): L = 29.17; H = 23. 96; W = 6. 29.

Remarks: The taxonomic status of this species requires assessment of previous records of Corbiculidae in the region, especially in the Paraná area, as some of the nominal species included in this group may be superficially similar to our material and may lead to confusion in its correct taxonomic placement and affinities.

The earliest species recorded that shows some resemblance to ***P. muravchiki***, nov. sp., is *Cyrena salobris* Ihering, 1907 (pp. 413–414, pl. 16, fig.109a, b). Ihering based this species on three specimens (MACN-HT 336) collected by Carlos Ameghino at Sierra Laziar, Santa Cruz Province, Argentina. Ihering placed this species in the subgenus *Pseudocyrena* Bourguignat, 1854, but the shell characters described by Ihering and examined by us in his original material suggest that it fits better in *Polymesoda*, as it shares the same hinge with three cardinal teeth, smooth anterior and posterior lateral teeth, short nymph, and very small pointed pallial sinus. It was later placed doubtfully in *Neocorbicula* by Parodiz (1969: 95–96, pl. 10, figs. 14, 15), because of the "general similarities". Ihering (1907) stated that he had three specimens, but later Ihering (1914: 41) mistakenly mentioned only two. Parodiz (1969: 95) stated that the "type" was a worn shell housed in the MACN, although he did not provide further information. However, he referred to the "type" as the figured specimen in his plate 10, figs. 14, 15 (Parodiz, 1969), which is a valid lectotype designation under the provisions of ICZN Article 74.5, as stated late by Parodiz (1996: 266). Del Río (1994: 109–110, text-fig. 2a, b) described

---

←

FIGS. 3–10. ***Polymesoda muravchiki*** nov. sp., scale = 2.5 cm. FIGS. 3, 4: Left valve MAS-PI-001 HT, internal view (Fig. 3: photograph, Fig. 4: drawing); FIGS. 5, 6: Left valve MAS-PI-001 HT, external view (Fig. 5: photograph, Fig. 6: drawing); FIGS. 7, 8: Right valve MAS-PI-008, internal view (Fig. 7: photograph, Fig. 8: drawing); FIGS. 9, 10: Right valve MAS-PI-008, external view (Fig. 9: photograph, Fig. 10: drawing).

Polymesoda (*Egeta*) *salobris* (Ihering, 1907) and stated that Ihering's figured specimen (Ihering, 1907: pl. 16, fig.109a, b) was the holotype. Under the name of *Polymesoda* (*Egeta*) *salobris* (Ihering, 1907), del Río (1994) also included material collected from the Puerto Madryn Formation at Fondeadero Ninfas, Chubut, northern Patagonia. This material (CPBA 14170/73; del Río & Martínez Chiappara, 1998b: pl. 9, figs. 1–3) is clearly different from Ihering's species, as the much larger shells have a more elongate, subtriangular shape and stronger commarginal lines; in addition the middle cardinal tooth is longer and the lateral cardinal teeth are shorter. All the type specimens of *Polymesoda salobris* (Ihering, 1907) are much smaller than our specimens. They are also more rounded and somewhat more elongate and wider than the new species, which is larger and with a more triangular shape than Ihering's. The cardinal and lateral teeth in the new species are weaker, as also are the umbones and the commarginal lines.

A second species apparently belonging in the Cyrenidae is *Corbicula* (*Corbiculella*) *tenuis* Ihering, 1907 (pp. 468–469, pl. 18, fig. 130a, b), based on material embedded in the matrix within *Diplodon fraus*, a freshwater bivalve collected by Bravard at Paraná, but probably from continental beds overlying the Paraná Formation. This species was based on fragmentary material now missing from Ihering's collection. The description is very general and the illustration is very poor – shedding no light on its true identity. Ihering stated that he had no complete specimen of this species, which had thin and fragile valves. He also stated that these were poorly inflated ("*peu ventrue*") and more or less oval-shaped, with a non-prominent umbo. In these and other characters, such as the obliquely ascending anterior and posterior margins, smooth outer surface, and general outline, this species may be confused with ***P. muravchiki***, especially as the drawing provided by Ihering (1907: pl. 18, fig. 130a, b) is very poor and no distinctive feature clearly depicted. However, in Ihering's description, he stated that the median cardinal tooth of the left valve is bifid, and that it has two anterior lateral teeth. These features – together with the purported lack of pallial sinus – are enough to clearly distinguish it from ***P. muravchiki***. Ihering proposed the new subgenus *Corbiculella* for *Corbicula tenuis*. Parodiz (1969: pp. 98–99, pl. 10, figs. 12, 13) reassigned it to *Neocorbicula*, while recognizing *Corbiculella* as a subgenus. Unfortunately, he did not provide any further description or illustration of new material, basing his comments on Ihering (1907). According to Parodiz (1969: 98), the specimen illustrated by Ihering represents two different left valves, but the poor drawings are inconclusive on this issue, although they do in fact appear to belong to the same specimen. Parodiz dismissed Ihering's statement on the lack of pallial sinus because it could not be seen on the illustrated syntype, but Ihering had additional specimens. According to Ihering (1914: 41) he had four specimens from Paraná ("cotypos", from the Bravard Collection; MACN-Pl #337, according to Parodiz, 1996) and additional material from La Paz collected by S. Roth (several specimens embedded in rock, the only ones presently remaining in Ihering's collection). Therefore, it seems reasonable that he would have recorded the presence of a pallial sinus in at least some of the specimens, as it appears to be a character that he would not have missed if present; he was probably sure enough of its absence to mention that fact in his description. In any event, even if superficially similar to the new species described herein, the two taxa are different and belong in different genera, in which case we would agree with Parodiz (1969) in placing it in *Corbiculella*. A decision on whether this is a subgenus of *Neocorbicula* or a different, unrelated group must wait until more data on the type species becomes available.

Polymesoda muravchiki easily fits in *Polymesoda* because of its shape and its characteristic hinge with smooth teeth. Previous inclusions of material referable to *Polymesoda* in any of the different subgeneric divisions (Keen & Casey, in: Moore, 1969) appear to be in need of revision and must wait until a general systematic study of the group is undertaken.

From *Polymesoda caroliniana* (Bosc, 1802), the type species of the genus, it can be distinguished by its much lower and inconspicuous umbos and its weaker lateral teeth (Van der Schalie, 1933). The Recent species also has a higher shell and the pallial sinus is deeper, more pointed and not directed as dorsally as in ***P. muravchiki***.

In these characters, it resembles more *Polymesoda arctata* (Deshayes, 1854), also Recent from the Caribbean coast of South and Central America. This species has a higher and more prominent umbo, and the ornamentation is far more conspicuous. The two species share the same type of pallial sinus, but the teeth are much stronger in the extant one.

A recent species that more closely resembles the fossil one described herein is *Polymesoda floridana* (Conrad, 1846), from the Caribbean coast of North America. Material examined by us (MLP-I-9846) shows that the shell outline and hinge are very similar to that of ***P. muravchiki***, but the lateral teeth are stronger in the living species. It also shows a more clearly defined posteroventral ridge.

Presently, the most austral species of this genus in South America is *Polymesoda notabilis* (Deshayes, 1855), which inhabits the Pacific coast near Tumbes, Peru. According to material of this species we examined (MACN-I-29222), it differs from ***P. muravchiki*** in its larger, inequilateral valves, and its lateral teeth are smaller and sharply pointed.

In the Argentine geological literature there are many references to *Neocorbicula stelzneri* Parodiz, 1969 (pp. 93–94 pl.11, figs. 2, 3), from localities in the northwestern area of the country and within rocks generally correlated with the Paraná Formation. However, the identity of the material referred to it remains uncertain, as most specimens housed in museums are only very badly preserved casts in which no interior characters are visible. Thus, any comparison with it is meaningless until specimens with visible hinges and pallial lines become available.

Order MYOIDA
Superfamily MYOIDEA
Family ERODONIDAE
Genus *Erodona* Bosc, 1802
Type Species *Erodona mactroides* Bosc, 1802;
subsequent designation by Dall, 1898

Erodona doellojuradoi nov. sp.
FIGS. 11–18

?*A. occidentalis* Ameghino, 1891: 89 (*nomen nudum*).

?*Corbula mactroides* Daud. var. *paranensis* Doello-Jurado (n. var.) – Frenguelli, 1920: 99 (*nomen nudum*).

Material: Two hundred and sixty specimens, 100 left valves and 160 right valves.

Type Material: MAS-PI-327, a left valve, is designated holotype (HT). Paratypes, MAS-PI-328/386, and DMT-PI-143/182, a left valve; MAS-PI-387/486 and DMT-PI-183/242, a right valve.

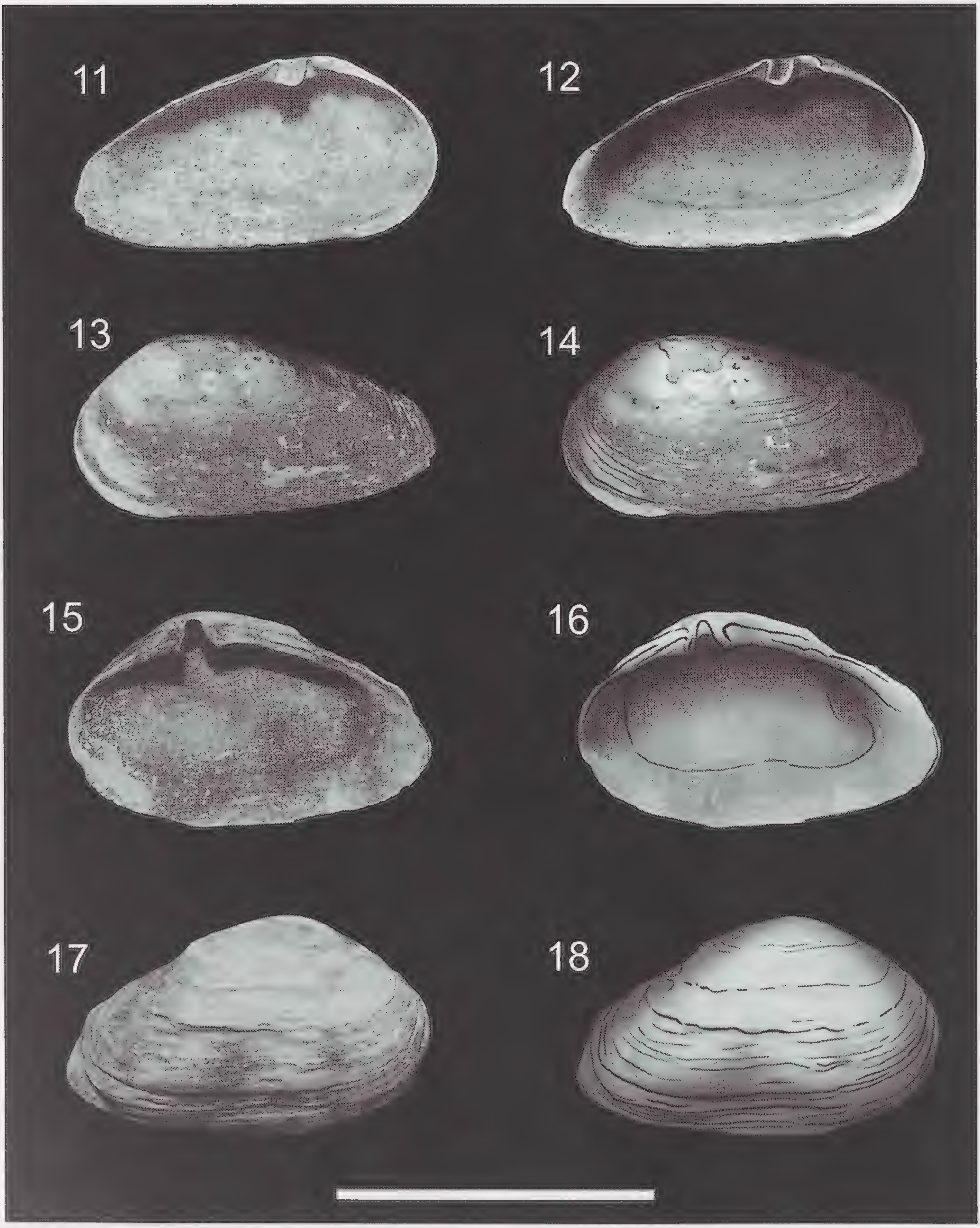
Type Locality: La Juanita (31°52'46"S, 60°38'59"W), near Aldea Brasilera, department of Diamante, Entre Ríos Province, Argentina.

Etymology: Honoring Martín Doello-Jurado, who recognized that this was a new taxon in 1920 (Frenguelli, 1920: 96).

Occurrence: Most specimens were found within the Paraná Formation at La Juanita. One specimen was found embedded in the matrix surrounding a specimen of *Anadara bonplandiana* (MLP 7908) labelled as from La Paz, Entre Ríos. A second specimen, a right valve (MLP 1819), comes from the Arroyo Los Galpones, nearby Paraná.

Diagnosis: Shell corbuliform, strongly inequivalve; umbones not prominent, placed at 0.38 of total length from anterior end; right valve with very shallow sulcus running from umbo to ventral margin; subtriangular asymmetric chondrophore pointing posteriorly, with concavity facing frontwards; posterior half of chondrophore almost perpendicular to commissure plane; anterior edge of chondrophore inner surface with narrow, weak but conspicuous groove.

Description: Shells thin, corbuliform, strongly inequivalve, inequilateral; commissure not lying in a plane; length between 9.65 and 31.31 mm and height between 6.14 and 15.89 mm (LV); length between 10.27 and 30.82 mm and height between 7.63 and 19.64 mm (RV). Right valve (Figs. 15, 16) umbo more prominent than that of left valve, placed at 0.38 of total length from anterior end; distinct umbonal ridge running nearly parallel to posterior margin, rendering posterior end truncate; very shallow sulcus running from umbo to ventral margin, originating an indistinct shallow depressed area on shell surface; left valve smaller, shallower than right valve; left valve umbones very indistinct, as well as shallow medial sulcus; hinge plate narrow, long; right valve hinge with two very weak cardinal teeth, diverging from umbo, border-



FIGS. 11–18. ***Erodona doellojuradoi*** nov. sp., scale = 2.5 cm. FIGS. 11, 12: Left valve MAS-PI-327 HT, internal view (Fig. 11: photograph, Fig. 12: drawing); FIGS. 13, 14: Left valve MAS-PI-327 HT, external view (Fig.13: photograph, Fig. 14: drawing); FIGS. 15, 16: Right valve MAS-PI-398, internal view (Fig. 15: photograph, Fig. 16: drawing); FIGS. 17, 18: Right valve MAS-PI-398, external view (Fig. 17: photograph, Fig. 18: drawing).

ing a deep triangular resilifer that is generally directed posteriorly; anterior cardinal tooth of right valve larger than lamellar posterior tooth; left valve hinge with a short, projecting chondrophore surrounded by sockets for the corresponding teeth of right valve; anterior socket larger, separated from chondrophore by a weak, low ridge running along posterior edge of chondrophore; a similar ridge, much sharper, separates the small anterior tooth socket from the chondrophore; shell isomyarian, with anterior adductor muscle scar reniform and slightly larger than subcircular posterior scar; anterior pedal retractor muscle scar small, subcircular, placed at mid-distance between umbo and anterior adductor muscle scar; pallial line well marked, with a very shallow, indistinct pallial sinus adjacent to posterior adductor muscle scar; external surface of shell smooth, with weak and regularly spaced commarginal growth lines.

Measurements: HT (MAS-PI-327): L = 22.06; H = 11.19; W = 3.91. Measured paratypes: MAS-PI-342/348/375 and DMT-PI-145/159/166, left valves; MAS-PI-398/399/437 and DMT-PI-188/194/217, right valves.

Remarks: Previous mentions in the literature that may be referable to this species were published by Frenguelli (1920). This author indicated the presence of isolated valves of "*Corbula mactroides* Daud. (= *Azara labiata* d'Orb.)", and he pointed out that it was previously unknown from Tertiary beds in Entre Ríos, and an important member of the fauna. On the other hand, in a footnote to his comment he quoted Doello-Jurado (*in littera*) who stated that this *Corbula* could not be identified with the extant *Azara labiata*, representing a variety or an immediate precursor to *Corbula mactroides,* presently living in the Río de La Plata estuary. He named it *Corbula mactroides* Daud. var. *paranensis*, n. var. (Frenguelli, 1920: 99) [*nomen nudum*]. *Erodona* was subsequently mentioned without illustration nor indication of species by Aceñolaza (2004: 27).

Erodona is represented in South America by its type species, *Erodona mactroides* Bosc, 1802, which inhabits mainly low salinity environments along the Atlantic coast of South America from the Lagoa dos Patos, Rio Grande do Su, Brazil (Rosa & Bemvenuti, 2006), to Punta Rasa, Buenos Aires Province, Argentina. This species was first described based on material collected from an unknown locality ("probably South Atlantic Ocean" according to Lamy, 1941) that has not been identified yet, but is probably the estuary of the River Plate (Maton, 1809). Representatives of *Erodona* have been mentioned from late Eocene rocks (Keen, in: Moore, 1969), but these references have not been confirmed and possibly belong in other genera. It has been recorded with certainty in Pleistocene and Holocene deposits of the same region (Wahnish, 1942; Camacho, 1967b; Aguirre, 1988, 1994; Farinati et al., 2006).

A few years later, d'Orbigny (1839: 573, pl. 72, fig. 22; 1842: 161) described *Azara labiata*. His material was collected from the Pampéen, Buenos Aires Province, near the town of San Pedro, about 60 km upstream from the mouth of the Paraná River.

The species was revised by Carcelles (1941), and he commented on its variability, affinities, and geographic range. He concluded that this species, although often mentioned in the literature since it was first described, had been erroneously identified. According to him, this was so in part because of the variability it shows and because of the poor knowledge then available on this variation. Most of the references in the literature are based on material collected by geologists carrying out field work often in connection with building sites in areas surrounding the city of Buenos Aires. It was also mentioned from localities along the Atlantic coast from São Paulo down to Punta Alta, near the city of Bahía Blanca, Buenos Aires Province (Farinati et al., 2006). References of this species also exist from Gualeguaychú, along the coast of the Uruguay River, about 250 km north of Buenos Aires, and from Atalaya and Río Salado, both located south of La Plata along the coast of Buenos Aires Province (Carcelles, 1941). Most of the material mentioned by Carcelles and previous authors is missing and thus such identifications could not be confirmed. Therefore, additional material housed in museums in Argentina (Museo Argentino de Ciencias Naturales "Bernardino Rivadavia", Buenos Aires and Museo de La Plata "Francisco Pascasio Moreno", La Plata) was analyzed. Such an analysis suggests that Carcelles´s ideas on the variability of this species were generally right. This is true at least for all the material collected from units now referred to the "Pampeano" and "Post-Pampeano", exposed between San Pedro and Bahía Blanca in Buenos Aires Province (Camacho, 1967b; Aguirre, 1988). The case is different with those references mentioned by Carcelles in which the material surely comes from older beds, for example, the specimens mentioned by Doering (1882: 405) from the "Araucano" of the Santa María Valley in Catamarca, western Argentina, which Ameghino (1891: 89) referred to as *A. occidentalis*. No description or illustration was provided, and therefore it should be considered a *nomen nudum*. However, further research in western Argentina proved the existence there of marginal marine rocks referred to the Entrerriense transgression (Herbst et al., 2000). Most likely, the material mentioned by Doering may belong in this new taxon.

A second doubtful reference of this species is by Szajnocha (1888), who reported it from Magallanes and Skyring Water, in southernmost Chile. However, this record appears to be referable to *Corbula*, as suggested by Ihering (1907) and Carcelles (1941).

The only Recent species of this genus, *Erodona mactroides*, is known to occur profusely in the Río de La Plata estuary, where if forms relatively large shell accumulations. It has also been reported from Lagoa dos Patos in southern Brazil (Bemvenuti et al., 1978; Geraldi, 2002; Rosa & Bemvenuti, 2006), Uruguay (Maldonado, Punta del Este, Playa Capurro, Montevideo, and Colonia del Sacramento), and in Argentina (Buenos Aires, Río Matanza, Río Santiago, Atalaya, Magdalena, Punta Indio, Punta Piedras, and Bahía de Samborombón). All these localities lie in the temperate areas of the Atlantic coast of South America, and are all in brackish environments in which the salinity ranges between 7 g/l and 20 g/l (Ríos, 1975; 1985). According to Da Costa (1971), it is more frequent in pre-mixohaline (8–15 g/l) and mixohaline (3–9 g/l) zones, becoming uncommon in pre-limnic zones in Lagoa dos Patos, southern Brazil. Sprechman (1978) considered it a genuine brackish species from mesohaline environments (3–18 g/l). Da Costa (1971) suggested that *Erodona mactroides* is a typically mixohaline taxon showing a distribution adapted to the environment. It has been mentioned neither from fully marine environments in the area, nor from clearly freshwater environments. The recorded stratigraphic range of the genus was Eocene? - Recent. However, the early Cenozoic records from South America seem to be incorrect, as the species actually involved can be now placed in other genera that, while similar to *Erodona*, are quite different. Aguirre (1994) summarized a synonymy list for *Erodona mactroides* and at the same time provided data on the distribution of this species in Quaternary deposits in Argentina.

Nuttall (1990) revised the faunas of non-marine mollusks from Cenozoic inland basins from northwestern South America. In this work, he stated that *Erodona* shows a very different hinge from that of *Pachydon* Gabb, 1869 (type species *Pachydon obliquus* Gabb, 1869), which is clearly visible in the specimens of several species figured by him. The hinge in *Pachydon* carries a strong peg-like cardinal tooth in the right valve, which is absent in *Erodona*, in which the anterior tooth, adjacent to the resilifer, is weak and narrowly blade-like. The chondrophore in the left valve of the southern genus is also different, as it lies at an angle to the commissure plane and its inner surface faces posteriorly.

A genus that in some ways is similar to *Erodona* is *Ostomya* Conrad, 1874 (type species *Ostomya papyria* Conrad, 1874). This genus, placed by Keen (in: Moore, 1969) in the Lyonsiidae Fischer, 1887, was allocated by Nuttall (1990) to the Corbulidae Lamarck, 1818. The hinge of the type species resembles the hinge of *Erodona*. In *Ostomya*, the right valve carries a narrow blade-like tooth very similar to that observed in *Erodona*. It fits in a correspondingly narrow socket in the left valve hinge. The resilifer is also inclined, although in *Erodona* it is proportionally better developed, and in the left valve it rests in a chondrophore that is facing posteriorly. As in *Ostomya*, the resilifer in the right valve is deeply sunken but it is far more strongly buttressed. The nymph in the left valve is entirely missing in *Erodona*, a feature that separates it from Conrad's genus. Also, the shells of *Ostomya* are thinner and more ovoid in shape than those generally observed in *Erodona*.

Worth mentioning is the case of *Anisothyris iquitensis* de Greve (1938), from Tertiary beds near Iquitos, Peru. Bristow & Parodiz (1982) suggested that this species was closer to *Erodona* than to *Anisothyris*, where it had been originally placed by de Greve (1938).

According to them, the main difference with *Erodona* was the posterior end of the shell, which is concave instead of convex, and has an obsolete filiform ligament along the marginal line at both sides of the umbo. They also stated that it is possible that *A. iquitensis* is a transitional form or a subgeneric intermediate between *Erodona-Anisothyris*, and related to the true marine *Corbula* (*Caryocorbula*). However, Nuttall (1990) believed that it belonged in *Pachydon* and allocated it to that genus. He also stated that a further specimen from the Cuenca Basin, Ecuador, discussed by Bristow & Parodiz (1982: 31) belonged in *Corbicula* (*Cyanocyclas*) *cojitamboensis* Palmer, in Liddle & Palmer (1941).

Erodona doellojuradoi can be separated from the type species by a number of characters. The fossil species has generally slightly larger shells than *Erodona mactroides*. The shell outline is also different, with a straighter ventral margin, which renders the shell generally more elongate, with H/L ratios of 0.56 (LV) and 0.61 (RV), in contrast to those of *Erodona mactroides* (0.64, LV and 0.66, RV; pers. obs.). The posterordorsal margin is very gently convex, whereas in *E. mactroides* it is straight or slightly concave. This feature renders the umbos less prominent than in the extant species and the posterior part of the shell is more rostrate. The hinge also shows differences, particularly in the development of the hinge plate, which is lower, narrower and more slender than in the type species. The cardinal teeth of the right valve are also more delicate. The chondrophore, while smaller, is clearly asymmetrical, as its posterior ridge is far more developed and higher than the anterior one. This assymetry gives the chondrophore its "anteriorly inclined" appearance. On the other hand, the chondrophore of the living species is larger, and the ridges are not much different from each other. Thus the chondrophore appears to lie more or less parallel to the commissure plane.

As in *Erodona mactroides*, ***Erodona doellojuradoi*** has a weak groove that borders the posterior edge of the chondrophore, but this groove is better defined in the extant species. Growth lines in ***E. doellojuradoi*** are weaker and more regularly placed than in *Erodona mactroides*, rendering the shell surface smoother. The shell is also thinner in the fossil species. Also, the shells are slightly less inflated in the fossil species (W/H = 0.34, LV, and 0.30, RV) than in the extant one (W/H = 0.37, LV, and 0.36, RV), a trait that remains consistent throughout ontogeny. While the shape of the shells from different populations of *Erodona mactroides* appears to be at least partly dependent on such environmental factors as salinity, temperature, the influence of these in the fossil populations remains yet to be ascertained.

Paleoenvironmental & Biogeographic Significance

The genus *Polymesoda* Rafinesque, 1828 (Mollusca: Bivalvia: Corbiculidae), is presently represented in America by several species living mainly in the Caribbean region. It is also known from the eastern Pacific (Gulf of California to northern Peru) and the Indo-Pacific (Woodward, 1964; Morton, 1976). Species of this genus inhabit silty substrata in brackish estuaries, mangroves, and near river mouths (Castaing et al., 1981; Marelli, 1990; García et al., 1994; De La Hoz Aristizábal, 2005, 2008). The genus is also known from Eocene to Recent deposits in North and Central America (Duobinis-Gray & Hackney, 1982; Rueda & Urban, 1998; Sarcos & Botero, 2005), and the Recent southernmost range is probably northern Peru (pers. obs., LMP); in Argentina the genus was recorded in the Pliocene (?) of Sierra Laziar, Santa Cruz Province, southern Patagonia. Records from the Late Miocene Puerto Madryn Formation by del Río (1994, 2000) and del Río & Martínez Chiappara (1998b) are referable to a different taxon.

The new species described herein – together with the new species of *Erodona* – comes from rocks referable to the Paraná Formation, exposed along the left margin of the Paraná River between the cities of Paraná and Diamante. These rocks have been variously interpreted as marine (del Río, 1991; del Río & Martínez Chiappara, 1998b), brackish (Aceñolaza, 1976), or as a calcareous reef (Aceñolaza & Aceñolaza, 2000). Our material occurs together with *Portlandia*, *Anadara*, *Amusium*, *Aequipecten*, *Placunanomia*, *Crassostrea*, *Mactra*, and *Chionopsis*. This faunal assemblage is a parautochtonous assemblage generated by tempest flows (Fürsich & Oschmann, 1986; Fürsich, 1993; Simões et al., 1994, 1995). Furthermore, some of the material is clearly reworked as suggested by its taphonomic attributes (e.g., fragmentation of *Crassostrea patagonica*). Thus, the genesis of the bearing sediments may be attributed to a chaotic storm deposit.

The geographic distribution of the species currently referred to *Polymesoda* includes estuaries, lagoons and river mouths at low latitudes along the Atlantic coast of North America, around the Caribbean Sea, the Pacific coast of America between the Gulf of California and northern Peru, and the Indo-Pacific Region (Woodward, 1964; Morton, 1976, 1985; Duobinis-Gray & Hackney, 1982; Ruiz Campos et al., 1998; Rueda & Urban, 1998; Sarcos & Botero, 2005). The occurrence of this genus in locations so far south from its present range, suggests that during the Late Miocene there could have been some pathway connecting these widely separated areas. As all extant species of this genus appear to be restricted to marginal brackish environments or freshwater, migration along the Atlantic coast of South America seems at least unlikely, even more so a Pacific migration around the southernmost tip of the continent. A possible explanation may lie in the probable connection between the Paraná and Amazon basins along a very shallow marginally marine sea arm running along the eastern foothills of the Andes at that time. Such a connection is not accepted by Wesselingh & Salo (2006), but according to Hernández et al. (2005), there may have been an incomplete connection only viable for euryhaline species that tolerated very low salinities or even freshwater conditions, and adapted to shallow estuarine environments. These would have had the dispersal capabilities necessary to invade the Paraná Sea and spread along its coastal areas as far South as the locality studied.

The exposure from where the material was collected carries a rich assemblage of marine taxa that has been assigned a Late Miocene age. These rocks were deposited during the Entrerriense ingression that covered part of central-northern Argentina, reaching as far north as Bolivia, Paraguay and southern Brazil. This taxon appears associated to other taxa that suggest normal salinity, contrasting with the brackish environment preferred by *Polymesoda* and other members of this fauna (i.e., *Erodona*). An alternative explanation to a storm deposit for this faunal assemblage of marine and strictly brackish taxa may be found in fluctuations in sea level. However, the taphonomic attributes of the shells present in the bearing bed – and also its sedimentologic features – point towards the first alternative.

If the marginal brackish conditions reached northwards at least temporarily to the southern boundary of the Amazonian Sea in the Late Miocene, then the paleobiogeographic distribution of this genus can be easily explained, in view of the paleoecological restrictions that such a connection may have imposed on other members of the fauna, while favoring the dispersion of brackish and freshwater taxa.

The extant *Erodona mactroides* lives presently in mainly brackish environments, such as the estuary of the River Plate, where it can be found as far inland as Tigre in Argentina and to the mouth of the estuary at Bahía Samborombón, Argentina, and Montevideo, Uruguay. The other records of this species also include similar environments, such as the Lagoa dos Patos in southern Brazil. According to Sprechman (1978), the range of salinity tolerated by *Erodona mactroides* lies between 3–18 g/l, i.e., typically mixohaline (Da Costa, 1971). However, along the coasts of the Río de la Plata, this range seems to be broader. The paleoenvironment in which the shell bed at La Juanita was deposited appears to be normal marine or nearly so, judging from its fossil assemblage (Table 1). Some of the species may be euryhaline, as is the case of *Polymesoda* (Pérez et al., 2008). However, other taxa included in this same shell bed appear to be clearly marine. This is the case of pectinids and barnacles. Among the shark teeth present are taxa now living in tropical marine environments of northern Brazil. There are chances that the fauna may be a post-mortem mixture of marine and brackish elements due to storm action. However, the shells show no evidence of significant transport, as many of the mollusks – even in cases in which the ligament is relatively weak – were preserved with both valves conjoined. Admittedly, some of the material – as is the case of the specimens of *Crassostrea patagonica* – may have been redeposited, but this is not the case with the great majority of the other taxa.

The presence of *Erodona* in Miocene beds of the Paraná Formation opens questions concerning the origin and evolution of the marine fauna contained in this stratigraphic unit. The present geographic range of the genus seems to be only a small fraction of the original range it occupied in this area of South America. The northernmost fossil record is the whole specimen from La Paz, Entre Ríos (Fig. 1, LP) found in the MLP collection (MLP 7908) within the matrix surrounding a specimen of *Anadara bonplandiana*. Second northernmost record is the specimen (MLP 1819) from Arroyo "Los

Galpones", just south of the city of Paraná (Fig. 1, LG).

In view of the present and fossil distribution of *Polymesoda* and *Erodona*, the presence of these two new species described from rocks included in the Late Miocene Paraná Formation suggests that at the time this unit was deposited there probably was at least a marginal connection between a southern arm of the Amazonian Sea and the northernmost reaches of the Paraná Basin, in a manner similar to the proposed lowland connection between the western Amazonia and the Magdalena basins in northern South America (Wesselingh & Macsotay, 2006), which were possibly linked by a wetland-lake area. The exact nature of the Paraná-Amazon connection remains yet to be ascertained, but the migration of representatives of these genera along the Atlantic coast of South America seems highly unlikely when their peculiar ecological requirements are considered.

ACKNOWLEDGMENTS

We thank Dr. Miguel O. Manceñido and Dr. Guido Pastorino for helpful suggestions. Dr. Gustavo Darrigran and Lic. Juan José Rustán kindly provided some of the references. Lic. Alejandro Otero and Mr. Jorge González are duly acknowledged for illustrations of the material. The staff of the Museo de Ciencias Naturales y Antropológicas "Prof. Antonio Serrano" provided logistic support during our stay in Paraná City. The CICYTTP (CONICET) is thanked for its support while at Diamante. Financial support was provided by: the IAS (International Association of Sedimentologists) and Facultad de Ciencias Naturales y Museo, UNLP (Student Grant to LMP); The Malacological Society of London (Travel Award to LMP and SGI); Universidad Nacional de La Pampa (Project I-179); and CONICET, Argentina (Research Scholarship to LMP).

LITERATURE CITED

ACEÑOLAZA, F. G., 1976, Consideraciones bioestratigráficas sobre el terciario marino de Paraná y alrededores. *Acta Geológica Lilloana*, 13: 2, 91–107.

ACEÑOLAZA, F. G., 2000, La Formación Paraná (Mioceno medio): estratigrafía, distribución regional y unidades equivalentes. Pp. 9–27, in: F. G. Aceñolaza & R. Herbst, eds., *El Neógeno de Argentina.* INSUGEO, Serie de Correlación Geológica, 14: 290 pp.

ACEÑOLAZA, F. G., 2004. Paleobiogeografía de la región Mesopotámica. Pp. 25–30, in: F. G. Aceñolaza, ed., *Temas de la biodiversidad del litoral fluvial argentino*. INSUGEO, Miscelánea, 12: 378 pp.

ACEÑOLAZA, F. G. & G. ACEÑOLAZA, 2000, Trazas fósiles del Terciario marino de Entre Ríos (Formación Paraná, Mioceno medio), República Argentina. *Boletín de la Academia Nacional de Ciencias*, 64: 209–233.

ACEÑOLAZA, F. G. & J. M. SAYAGO, 1980, Análisis preliminar sobre la estratigrafía, morfodinámica y morfogénesis de la región de Villa Urquiza, provincia de Entre Ríos. *Acta Geológica Lilloana*, 15(2): 139–154.

AGUIRRE, M., 1988, Moluscos bentónicos marinos del Pleistoceno superior-Holoceno en el Noreste Bonaerense. Tesis Doctoral Nº 506, Facultad de Ciencias Naturales y Museo (UNLP), unpublished, 558 pp.

AGUIRRE, M., 1994, Type specimens of quaternary marine bivalves from Argentina. *Ameghiniana*, 31(4): 347–374.

AMEGHINO, F., 1891, Sobre algunos restos de mamíferos fósiles, recogidos por el señor Manuel B. Zabaleta en la formación miocena de Tucuman y Catamarca. *Revista Argentina de Historia Natural*, 1(2): 88–101.

AMEGHINO, F., 1906, Les formations sédimentaires du Crétacé superieur et du Tertiarie de Patagonie avec une paralléle entre leurs faunes mammalogiques et celles de l'ancient continent. *Anales del Museo Nacional de Historia Natural*, (Ser. 3), 15: 1–568.

BEMVENUTI, C. E., R. R. CAPITOLI & N. M. GIANUCA, 1978, Estudos de ecologia bentônica na região estuarial da Lagoa dos Patos. II – Distribução cuantitativa do macrobentos infralitoral. *Atlântica*, 3: 23–32.

BORCHERT, A., 1901, Die Molluskenfauna und das Alter der Paraná-Stufe. *Neues Jarhbuch für Mineralogie, Geologie und Paläontologie*, 14: 1–78.

BOURGUIGNAT, J. R., 1854, Aménités malacologiques. *Revue et Magasin de Zoologie Pure et Appliquée*, (Sér. 2), 6: 673.

BRAVARD, A., 1858, *Monografía de los terrenos marinos Terciarios de las cercanías del Paraná.* Imprenta del registro Oficial, Paraná, 107 pp. [Reimpresión Imprenta del Congreso de la Nación, 1995].

BRISTOW, C. R. & J. J. PARODIZ, 1982, The stratigraphical paleontology of the Tertiary nonmarine sediments of Ecuador. *Bulletin of Carnegie Museum of Natural History*, 19: 1–53.

BOSC, L. A. G., 1802, Histoire naturelle des coquilles, contenant leur description, les moeurs des animaux qui les habitent et leurs usages: avec figures dessinées d'après nature (Coquilles 2), Vol. 56. Pp. 1–330, in: G. L. L. Buffon, *Histoire naturelle de Buffon, classée par ordres, genres et espèces, d'après le systéme de Linné, avec les charactères génériques et la nomenclature Linnéenne*. Imprimerie de Crapelet, Paris.

CAMACHO, H., 1967a, Las transgresiones del Cretácico Superior y del Terciario de la Ar-

gentina. *Revista de la Asociación Geológica Argentina*, 12: 253–280.

CAMACHO, H., 1967b, Fascículo III. Invertebrados. Pp. 160, in: A. V. Borrelo, ed., *Paleontografia Bonaerense*. Publicaciones de la CIC. Buenos Aires (for 1966).

CAMPOS, E. R., J. C. CABRERA PEÑA, R. A. CRUZ & J. A. PALACIOS, 1998, Crecimiento y ciclo reproductivo de *Polymesoda radiata* (Bivalvia: Corbiculidae) en Costa Rica. *Revista de Biología Tropical*, 46(3): 643–648.

CARCELLES, A., 1941, *Erodona mactroides* en el Río de la Plata. *Physis*, 19: 11–21.

CASTAING, A., J. M. JIMÉNEZ & C. R. VILLALOBOS, 1981, Observaciones sobre la ecología de manglares de la costa Pacífica de Costa Rica y su relación con la distribución del molusco *Geloina inflata* (Philippi) (Pelecypoda: Corbiculidae). *Revista de Biología Tropical*, 28(2): 323–339.

CIONE, A. L., M. M. AZPELICUETA, M. BOND, A. A. CARLINI, J. R. CASCIOTTA, M. A. COZZUOL, M. DE LA FUENTE, Z. GASPARINI, F. J. GOIN, J. NORIEGA, G. J. SCILLATO-YANÉ, L. SOIBELZON, E. P. TONNI, D. VERZI & M. G. VUCETICH, 2000, Miocene vertebrates from Entre Ríos province, eastern Argentina. Pp. 191–237, in: F. G. Aceñolaza & R. Herbst, eds., *El Neógeno de Argentina*. INSUGEO, Serie de Correlación Geológica, 14: 290 pp.

CIONE, A. L., J. MENNUCCI, L. M. PÉREZ & M. J.BARLA, 2008, *Megascyliorhinus trelewensis* (Neoselachii) in the Middle-Upper Miocene of Paraná, Central eastern Argentina. Temas de la biodiversidad del litoral fluvial argentino III. *Miscelánea INSUGEO*, 17(1): 41–48.

CONRAD, T. A., 1846, Descriptions of new species of fossil and Recent shells and corals. *Proceedings of the Academy of Natural Sciences of Philadelphia*, 3: 19–27.

CONRAD, T. A., 1874, Remarks on the Tertiary clay of the Upper Amazon with descriptions of new shells. *Proceedings of the Academy of Natural Sciences of Philadelphia*, 1874: 25–32.

CORDINI, I. R., 1949, Contribución al conocimiento de la geología económica de Entre Ríos. *Anales de la Dirección Nacional de Minería*, 2: 1–78.

DA COSTA, C. M., 1971, Importancia paleoecológica e estratigráfica de *Erodona mactroides* Daudin (Mollusca, Bivalvia). *Iheringia Geologia*, 4: 3–19.

DALL, W. H., 1898, Contributions to the Tertiary fauna of Florida, with especial reference to the Miocene Silex beds of Caloosahatchie river. *Transactions of the Wagner Free Institute of Science of Philadelphia*, 3(4): 571–947.

DARWIN, C., 1839, *Narrative of the surveying voyages of his Majesty's ships Adventure and Beagle between the years 1826 and 1836, describing their examination of the southern shores of South America and the Beagle's circumnavigation of the globe*. Colburn, London, 3: 615 pp.

DARWIN, C., 1846, *Geological observations on South America. Being the third part of the geology of the voyage of the Beagle, under the command of Capt. Fitzroy, R. N. during the years 1832 to 1836*. Smith, Elder & Co., Cornhill, London, 279 pp.

DE GREVE, L., 1938, Eine Molluskenfauna aus dem Neogen von Iquitos am Oberen Amazonas in Peru. *Abhandlungen der Schweizerischen Paläontologischen Gesellschaft*, 61: 1–133.

DE LA HOZ ARISTIZÁBAL, M. V., 2005, Estado actual de la almeja estuarina *Polymesoda solida* como recurso ecológia en la Isla de Salmanca (Caribe Colombiano). *VI Congreso Latinoamericano de Malacología, Ciudad de Panamá - Panamá. Resúmenes*: 121.

DE LA HOZ ARISTIZÁBAL, M. V., 2008, Introducción a un enfoque metapoblacional para la conservación de *Polymesoda solida* (Bivalvia: Corbiculidae) en le Parque Natural Isla de Salamanca (Colombia). *VII Congreso Latinoameriano de Malacologia, Valdivia - Chile. Resúmenes*: 57–58.

DEL RÍO, C. J., 1990, Composición, origen y significado paleoclimático de la malacofauna "Entrerriense" (Mioceno medio) de la Argentina. *Anales de la Academia Nacional de Ciencias Exactas Físicas y Naturales. Buenos Aires*, 42: 205–224.

DEL RÍO, C. J., 1991, Revisión sistemática de los bivalvos de la Formación Paraná (Mioceno Medio) provincia de Entre Ríos - Argentina. *Monografía de la Academia Nacional de Ciencias Exactas, Físicas y Naturales. Buenos Aires*, 7: 11–93.

DEL RÍO, C. J., 1994, Middle Miocene bivalves of the Puerto Madryn Formation, Valdes Peninsula, Chubut Province, Argentina (Lucinidae - Pholadidae) Part II. *Palaeontographica*, (Abt. A), 231: 93–132.

DEL RÍO, C. J. & S. A. MARTÍNEZ CHIAPPARA, 1998a, El Mioceno en la Argentina y en el Uruguay. *Monografía de la Academia Nacional de Ciencias Exactas, Físicas y Naturales. Buenos Aires*, 15: 6–25.

DEL RÍO, C. J. & S. A. MARTÍNEZ CHIAPPARA, 1998b, II. 2 - Clase Bivalvia Linné, 1758. *Monografía de la Academia Nacional de Ciencias Exactas, Físicas y Naturales. Buenos Aires*, 15: 48–151.

DEL RÍO, C. J., 2000, Malacofauna de las Formaciones Paraná y Puerto Madryn (Mioceno marino, Argentina): su origen, composición y significado bioestratigráfico. Pp. 77–101, in: F. G. Aceñolaza & R. Herbst, eds., *El Neógeno de Argentina*. INSUGEO, Serie de Correlación Geológica, 14: 290 pp.

DESHAYES, G. P., 1854, Descriptions of new species of shells in the collection of Mr. Cuming. *Proceedings of the Zoological Society of London*, 22: 62–72.

DESHAYES, G. P., 1855, Descriptions of new species of shells in the collection of Mr. Cuming. *Proceedings of the Zoological Society of London*, 22: 317–371.

DOERING, A., 1882, *Informe oficial de la comisión científica agregada al Estado Mayor General de la Expedición al Río Negro (Patagonia) realizada en los meses de Abril, Mayo y Junio de 1879, bajo las órdenes del General D. Julio A.*

Roca. Parte 3 (Geología). Imprenta de Otwald y Martínez, Buenos Aires, pp. 300–530.

DUOBINIS-GRAY, E. & C. T. HACKNEY, 1982, Seasonal and spatial distribution of the Carolina marsh clam *Polymesoda caroliniana* (Bosc) in a Mississippi tidal marsh. *Estuarios*, 5(2): 102–109.

FARINATI, E. A., J. O. SPAGNUOLO & S. ALIOTTA, 2006, Bioerosión en micromoluscos holocenos del estuario de Bahia Blanca, Argentina. *Ameghiniana*, 43(1): 45–54.

FISCHER, P. H., 1887 [1880–1887], *Manuel de conchyliologie et de paléontologie conchyliologique*. Librairie F. Savy, Paris, xxiv + 1,369 pp.

FRENGUELLI, J., 1920, Contribución al conocimiento de la geología de Entre Ríos. *Boletín Academia Nacional de Ciencias* (*Córdoba*), 24: 55–256.

FRENGUELLI, J., 1947, Nota de geología entrerriana. *Revista de la Asociación Geológica Argentina*, 12: 127–140.

FÜRSICH, F. T. & W. OSCHMANN, 1986, Storm shell beds of *Nanogyra virgule* in the Upper Jurassic of France. *Neues Jahrbuch für Geologie und Paläontologie, Abhandlungen*, 172: 141–161.

FÜRSICH, F. T., 1993, Shell beds as tool in basin analysis: the Jurassic Kachchh, western India. *Journal of the Geological Society of London*, 150: 169–185.

GABB, W. M., 1869, Descriptions of fossils from the clay deposits of the Upper Amazon. *American Journal of Conchology*, 4: 197–200.

GARCÍA, Y., H. J. SEVEREYN & J. J. EWALD, 1994, Early development of the estuarine mollusk *Polymesoda solida* (Philippi, 1846) (Bivalvia: Corbiculidae) in Lake Maracaibo Venezuela. *American Malacological Bulletin*, 11(1): 51–56.

GERALDI, R. M., 2002, *Distribuição espacial, recrutamento, crescimento e mortalidade de Erodona mactroides Bosc, 1802 (Mollusca, Pelecypoda) na Lagoa dos Patos, RS, Brasil*. Tese de Oceanografia Biológica, Universidade Federal do Rio Grande, Rio Grande, 166 pp.

HERBST, R., L. M. ANZÓTEGUI, L. R. MAUTINO, S. MORTON & N. NASIF, 2000, Síntesis paleontológica del Mioceno de los valles Calchaquíes, noroeste argentino. *Serie de Correlación Geológica*, 14: 263–288.

HERNÁNDEZ, R. M., T. E. JORDAN, A. DALENZ FARJAT, L. ECHAVARRÍA, B. D. IDLEMAND & J. H. REYNOLDS, 2005, Age Distribution, tectonics, and eustatic controls of the Paranense and Caribbean marine transgressions in southern Bolivia and Argentina. *Journal of South American Earth Sciences*, 19: 495–512.

IHERING, H., 1907, Les mollusques fossiles du Tertiaire et du Crétacé Supérieur de l'Argentine. *Anales del Museo Nacional de Buenos Aires*, (Ser. 3), 7: 1–611.

IHERING, H., 1914, Catalogo de moluscos Cretáceos e Terciarios da Argentina da collecção do auctor. *Notas Preliminares da Revista do Museu Paulista*, 1(3): 1–148.

IRIONDO, M., 1973, Análisis ambiental de la Formación Paraná en su área tipo. *Boletín de la Asociación Geológica de Córdoba*, 2(1–2): 19–23.

KANTOR, M., 1925, La Formación Entrerriana. *Anales de la Sociedad Científica Argentina*, 50: 35–66.

LAMARCK, J. B. P. A., 1818, *Histoire des animaux sans vertébres*, vol. 5. Verdière, Paris, 612 pp.

LAMY, E., 1941, Revisión des Corbulidae vivants du Muséum Nacional d´Histoire Naturelle de Paris. *Journal de Conchyliologie*, 84(1–3): 1–23.

LIDDLE, R. A. & K. W. PALMER, 1941, The geology and paleontology of the Cuenca-Azogues-Biblian region, provinces of Canar and Azuay, Ecuador. *Bulletins of American Paleontology*, 26: 357–418.

MARELLI, D. C., 1990, Recruitment of the estuarine soft-bottom bivalve *Polymesoda caroliniana* and its influence on the vertical distribution of adults. *The Veliger*, 33: 222–229.

MATON, W. G., 1809, Description of seven new species of Testacea. *Transactions of the Linnean Society of London*, 11: 325 pp.

MOORE, R. C., 1969, *Treatise on Invertebrate Paleontology*. Part N, Vol. 2, Mollusca 6: Bivalvia. Geological Society of America and University of Kansas Press, Lawrence, pp. 491–952.

MORTON, B., 1976, The biology and functional morphology of the Southeast Asian mangrove bivalve, *Polymesoda* (*Geolina*) *erosa* (Solander) (Bivalvia: Corbiculidae). *Canadian Journal of Zoology*, 54(4): 482–500.

MORTON, B., 1985, The reproductive strategy of the mangrove bivalve *Polymesoda* (*Geloina*) *erosa* (Bivalvia: Corbiculoidea) in Hong Kong. *Malacological Review*, 18: 83–89.

MURAVCHIK, M., M. GRIFFIN & L. M. PÉREZ, 2004, Bryozoans from the Paraná Formation (Miocene), in Entre Ríos Province, Argentina. *Ameghiniana*, 41 (1): 3–12.

NUTTALL, C. P., 1990, A review of the Tertiary non-marine molluscan faunas of the Pebasian and other inland basins of north-western South America. *Bulletin British Museum*, (Geology Ser.), 45(2): 165–371.

ORBIGNY, A. d', 1839, *Voyage dans l' Amerique méridionale* (*le Brésil, la République Argentine, la Patagonie, la République du Chili, la République de Bolivie, la République du Pérou*), *executé pendant les années 1826–1833*, Tome 3, 4e part, Paléontologie. P. Bertrand, Paris & Ve. Levrault, Strasbourg, 7 pls.

ORBIGNY, A. d', 1842, *Voyage dans l' Amerique méridionale* (*le Brésil, la République Argentine, la Patagonie, la République du Chili, la République de Bolivie, la République du Pérou*), *executé pendant les années 1826–1833*, Tome 3, 4e part, Paléontologie. P. Bertrand, Paris & Ve. Levrault, Strasbourg, 188 pp.

PARODIZ, J. J., 1969, The tertiary non-marine Mollusca of South America. *Annals of Carnegie Museum*, 40: 1–242.

PARODIZ, J. J., 1996, The taxa of fossil Mollusca introduced by Hermann von Ihering. *Annals Carnegie Museum*, 65(3): 183–296.

PÉREZ, L. M., A. CIONE, M. GRIFFIN & M. MURAVCHIK, 2001, Estancia La Juanita, una nueva localidad con invertebrados y vertebrados de la Formación Paraná (Mioceno de la provincia de Entre Ríos, Argentina). *Ameghiniana*, 38(4): 40R.

PÉREZ, L. M., S. F. GENTA ITURRERÍA & M. GRIFFIN, 2008, Paleoecological and paleobiogeographic significance of a new species of *Polymesoda* Rafinesque, 1828 (Mollusca: Bivalvia: Corbiculidae) in the Paraná Formation (Late Miocene) of Entre Ríos province, Argentina. *VII Congreso Latinoamericano de Malacología. Valdivia - Chile. Resúmenes*: 10.

PÉREZ, L. M., M. GRIFFIN & A. ALUZA, 2005, El género *Erodona* Bosc, 1801 (Mollusca: Bivalvia: Myoidea) en la Formación Paraná (Mioceno superior), Entre Ríos, Argentina. *XIX Congresso Brasileiro de Paleontología & VI Congresso Latino - Americano de Paleontología*. [CD-ROM] Aracaju, Sergipe, Brasil.

PHILIPPI, R. A., 1893, Descripción de algunos fósiles Terciarios de la República Argentina. *Anales del Museo Nacional de Chile*, Tercera sección - Minerí, Geología y Paleontología, 1893: 1–16.

RAFINESQUE, C. S., 1828, Monographie des coquilles bivalves et fluviatiles de la riviére Ohio. *Annales Generales des Sciences Pysisques, Bruxelles*, 5: 287–322.

RIOS, E. C., 1975, *Brazilian marine mollusks iconography*. Museu Oceanográfico da FURG, Rio Grande, 311 pp.

RIOS, E. C., 1985, *Seashells of Brazil*. Museu Oceanográfico da FURG, Rio Grande, 328 pp.

ROSA, L. C. & C. E. BEMVENUTI, 2006, Temporal variability of the estuarine macrofauna of the Patos Lagoon, Brazil. *Revista de Biología Marina y Oceanografía*, 41(1): 1–9.

RUEDA, M. & H. J. URBAN, 1998, Population dynamics and fishery of the fresh-water clam *Polymesoda solida* (Corbiculidae) in Cienaga Poza Verde, Salamanca Island, Colombian Caribbean. *Fisheries Research*, 39: 75–86.

RUIZ CAMPOS, E., J. CABRERA PEÑA, R. Á. CRUZ SOTO & J. A. PALACIOS, 1999, Crecimiento y ciclo reproductivo de *Polymesoda radiata* (Bivalvia: Corbiculidae) en Costa Rica. *Revista de Biología Tropical*, 46(3): 643–648.

SARCOS, M. & L. BOTERO, 2005, Calidad microbiológica de la almeja *Polymesoda solida* recolectada en playas del Municipio Miranda del estado Zulia. *Ciencia*, 13(1): 34–43.

SIMÕES, M. G., F. F. TORELLO & A. C. ROCHA–CAMPOS, 1994, Proximal storm shell beds or coquinas in the Corumbataí Formation (*Pinzonella illusa* assemblage; Late Permian) in Rio Claro, SP, Paraná Basin, Brazil. In: *38° Congresso Brasileiro de Geologia*, Balneário Camporiú, Boletim de Resumos Expandidos: 226–227.

SIMÕES, M. G., F. F. TORELLO & A. C. ROCHA-CAMPOS, 1995, A storm-generated coquina (*Pinzonella neotropica* assemblage), Paraná Basin, Brazil. In: *XVI Congresso Brasileiro de Paleontologia*, Uberaba, MG. Atas, 126 pp.

SPRECHMAN, P., 1978, The paleoecology and paleogeography of the Uruguayan coastal area during the Neogene and Quaternary. *Zitteliana*, 4: 3–72.

STANLEY, S. M., 1970, Relation of shell form to life habits of the Bivalvia (Mollusca). *The Geological Society of America, Memoir*, 125: 1–296.

SZAJNOCHA, L., 1888, Über die von Dr. Rudolf Zuber in Süd-Argentina und Patagonien gesammelten Fossilien. *Verhandlungen der Kaiserlich-Koeniglich Geologischen Reichanstalt*, 6: 146–151.

VAN DER SCHALIE, H., 1933, Notes on the brackish water bivalve *Polymesoda caroliniana* (Bosc). *Occasional Papers of the Museum of Zoology*, University of Michigan, 258: 1–8.

WAHNISH DE CARRAL TOLOSA, E., 1942, Notas sobre los moluscos procedentes de la perforación Monte Veloz (Buenos Aires). *Anales Primer Congreso Panamericano Minas y Geología*, Geol. II: 562–579.

WESSELINGH, F. P. & O. MACSOTAY, 2006, *Pachydon hettneri* (Anderson, 1928) as indicator for Caribbean - Amazonian lowland connections during the Early - Middle Miocene. *South American Earth Sciences*, 21: 49–53.

WESSELINGH, F. P. & J. A. SALO, 2006, A Miocene perspective on the evolution of the Amazonian biota. *Scripta Geologica,* 133: 339–358.

WOODWARD, F. R., 1964, Studies on *Polymesoda expansa* (Mousson) (Corbiculidae, Bivalvia) from the Bismarck Archipelago. *Dansk Naturhistorisk Forening (Copenhagen), Videnskabelige Meddelelser*, 127: 149–158.

YRIGOYEN, M., 1969, Problemas estratigráficos del Terciario de Argentina. *Ameghiniana*, 6(4): 315–329.

ZABERT, L. L., 1978, Micropaleontología de la Formación Paraná (Mioceno superior) en el subsuelo de la provincia de Santa Fé, República Argentina. *FACENA*, 2: 101–165.

Revised ms. accepted 9 February 2010